Barcelona Supercomputing Center
Centro Nacional de Supercomputación

EXCELENCIA SEVERO OCHOA

Dust assimilation activities at the Barcelona Supercomputing Center

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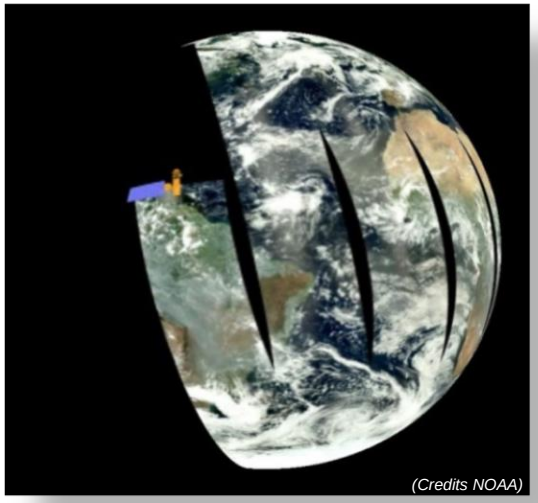
24/05/2018

9th International Workshop on Sand / Dust storms and Associated Dustfall, Tenerife, Spain

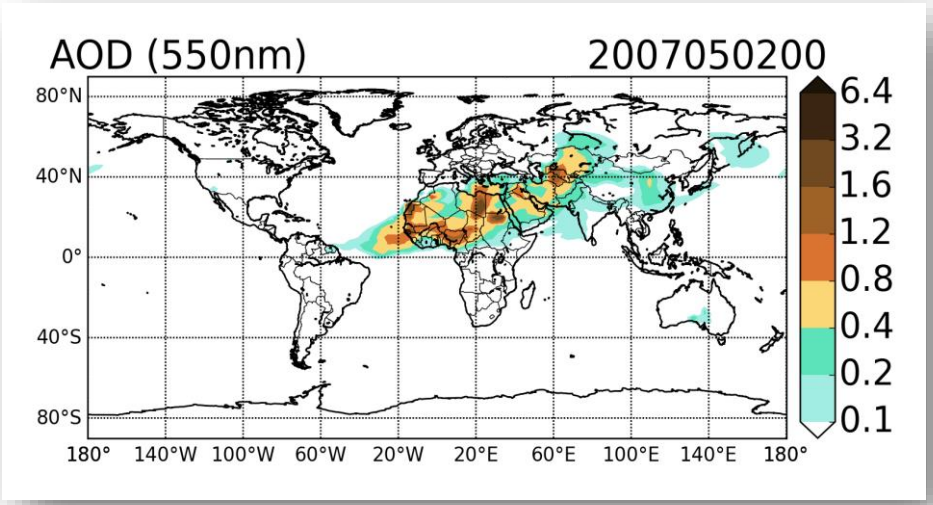
Data assimilation

Satellite observations



MODIS swath on the NASA polar orbiting satellite Aqua

Model simulations

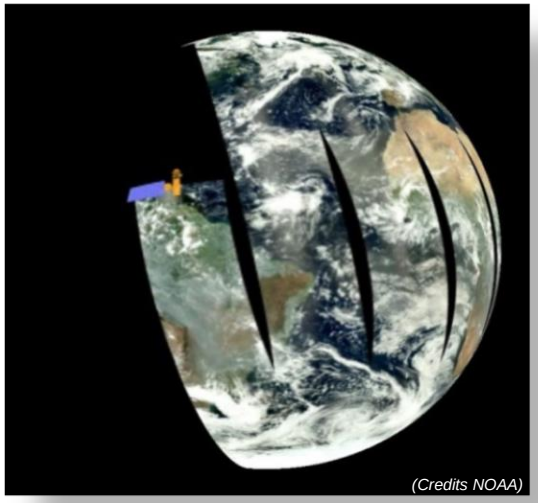


Dust optical depth simulated by NMMB-MONARCH

Data assimilation combines model simulations and observations to obtain the 'best' estimate of current atmospheric conditions (analysis)

Data assimilation

Satellite observations



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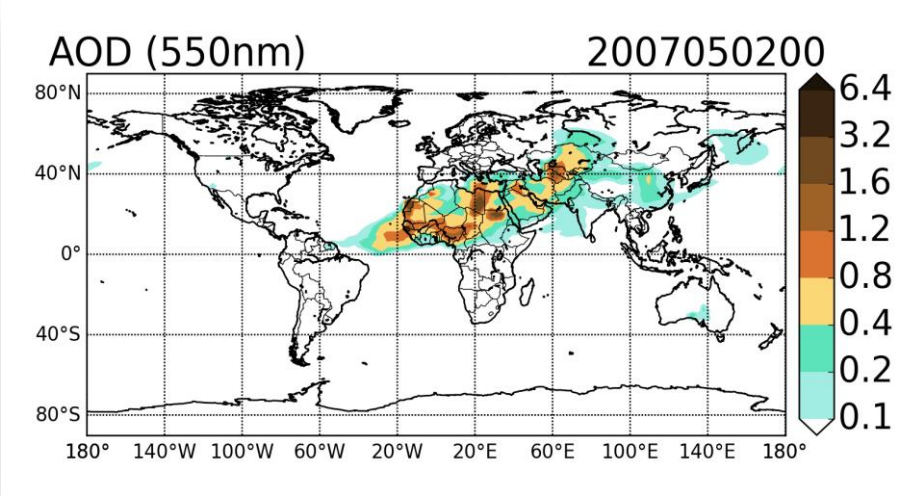

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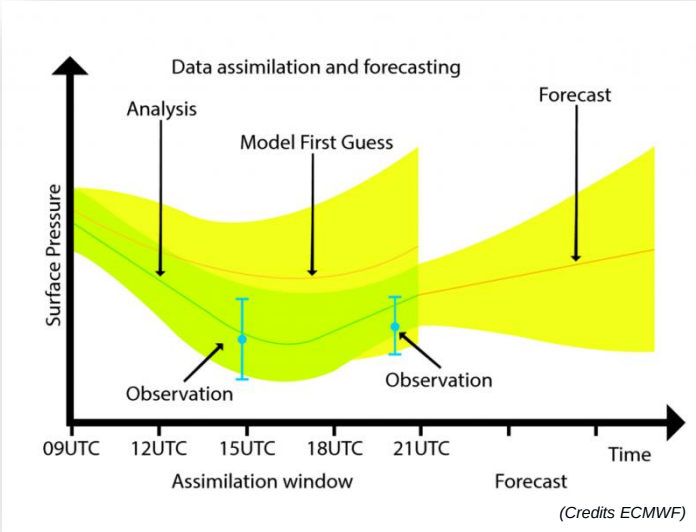

Data assimilation

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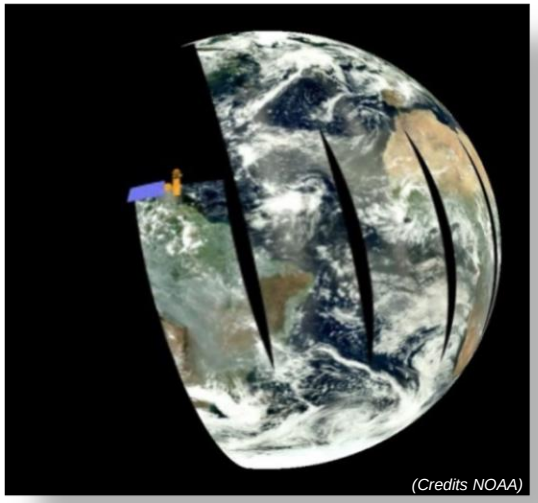

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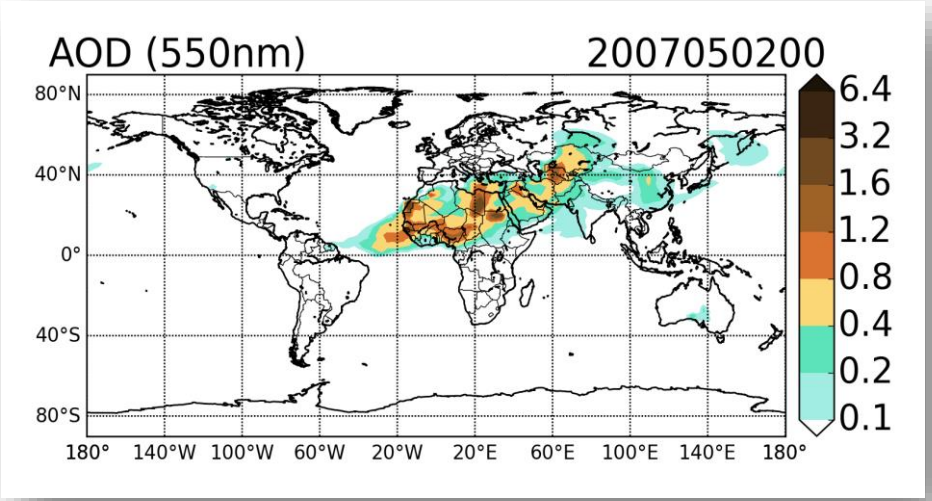
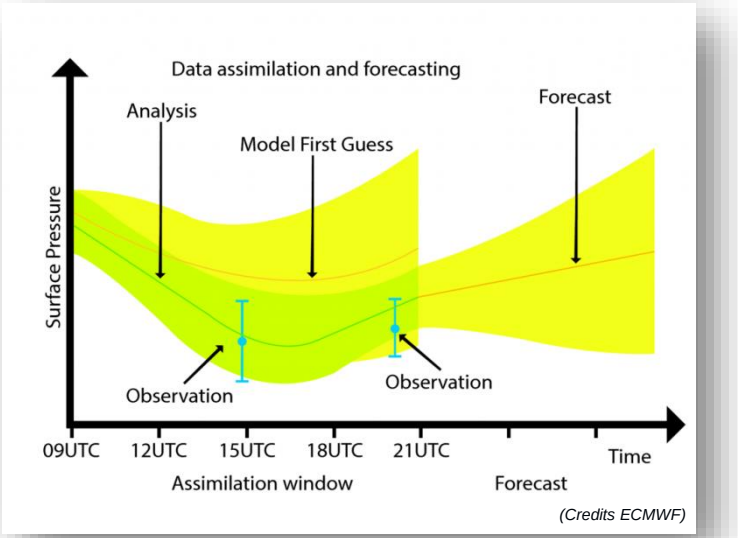


Dust optical depth simulated by NMMB-MONARCH

Data assimilation combines model simulations and observations to obtain the 'best' estimate of current atmospheric conditions (analysis)

-> *useful to initialise models and improve predictions*

→ *used to produce reanalysis*



Motivation

Operational **dust forecast** and **dust reanalyses** are produced in the framework of aerosol data assimilation, where **total AOD** is used to constrain all the main aerosol species

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Operational **dust forecast** and **dust reanalyses** are produced in the framework of aerosol data assimilation, where **total AOD** is used to constrain all the main aerosol species

Assess the potential benefit of dedicated dust observation products in dust data assimilation

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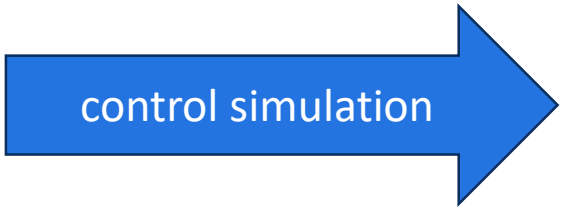
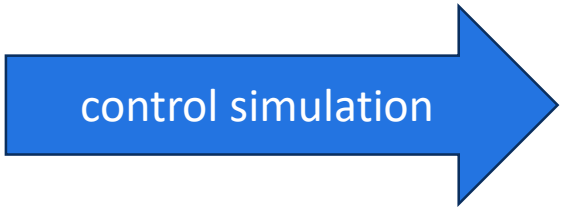
Experiment design



Dust component of the NMMB-MONARCH chemical weather system (Pérez et al., 2011)

Experiment design



Dust component of the NMMB-MONARCH chemical weather system (Pérez et al., 2011)

NMMB-MONARCH ensemble members are obtained perturbing uncertain model.

Experiment design

control simulation

Dust component of the NMMB-MONARCH chemical weather system (Pérez et al., 2011)

ensemble forecast

NMMB-MONARCH ensemble members are obtained perturbing uncertain model.

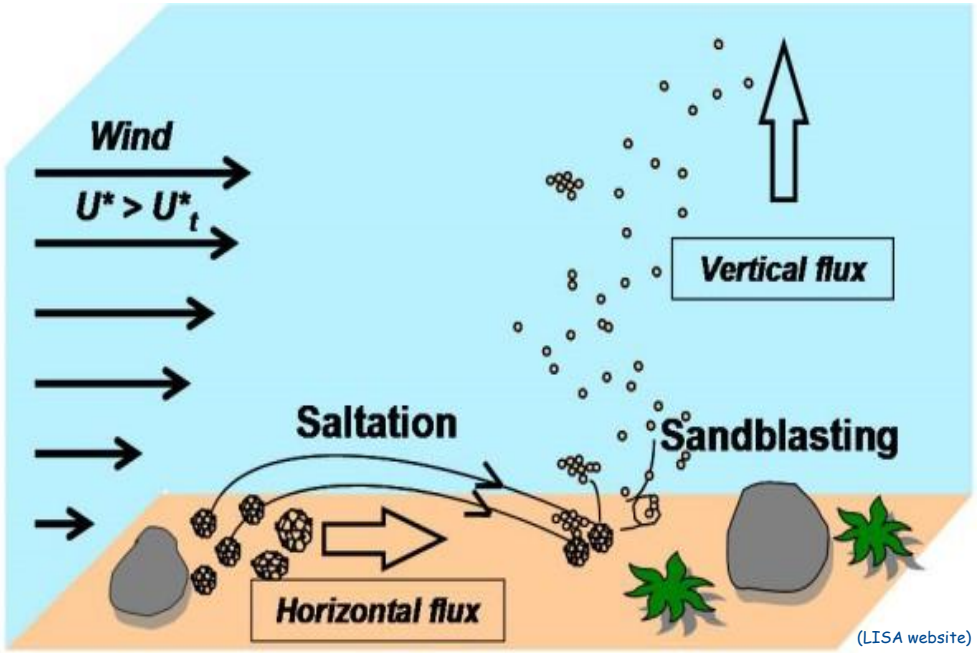
Role of B matrix:

- spatial spreading of information from observations
- statistically consistent increments between neighbouring grid points
- multivariate analysis

Generation of ensemble forecast

The ensemble forecast has been designed considering model uncertainties with respect to:

- **surface winds,**
- **soil humidity,**
- **vertical flux distribution at sources,**



(LISA website)

Generation of ensemble forecast

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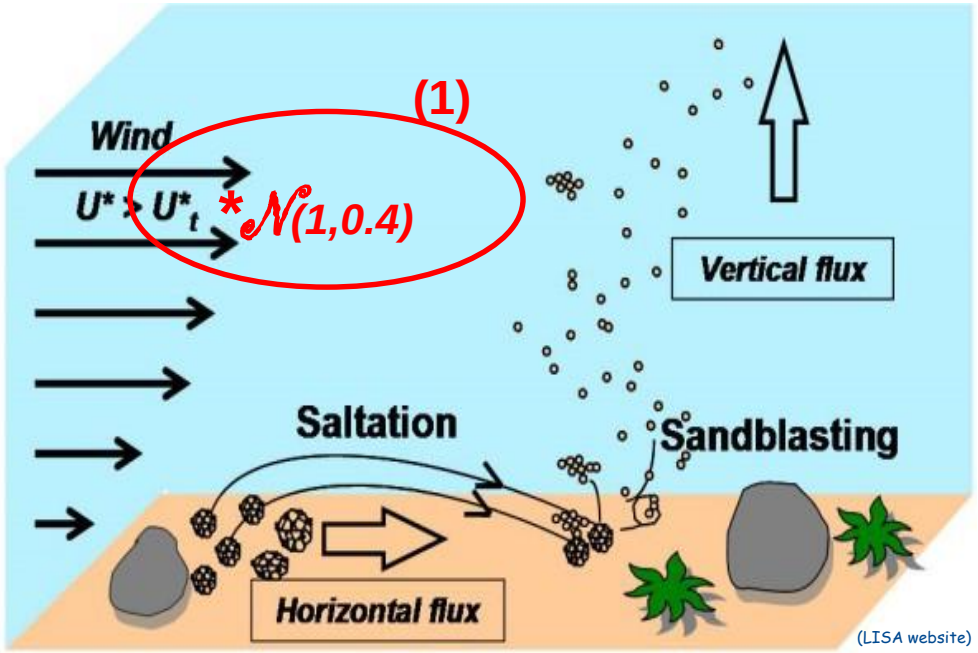
by perturbing:

(1) the threshold friction velocity



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- **surface winds,**
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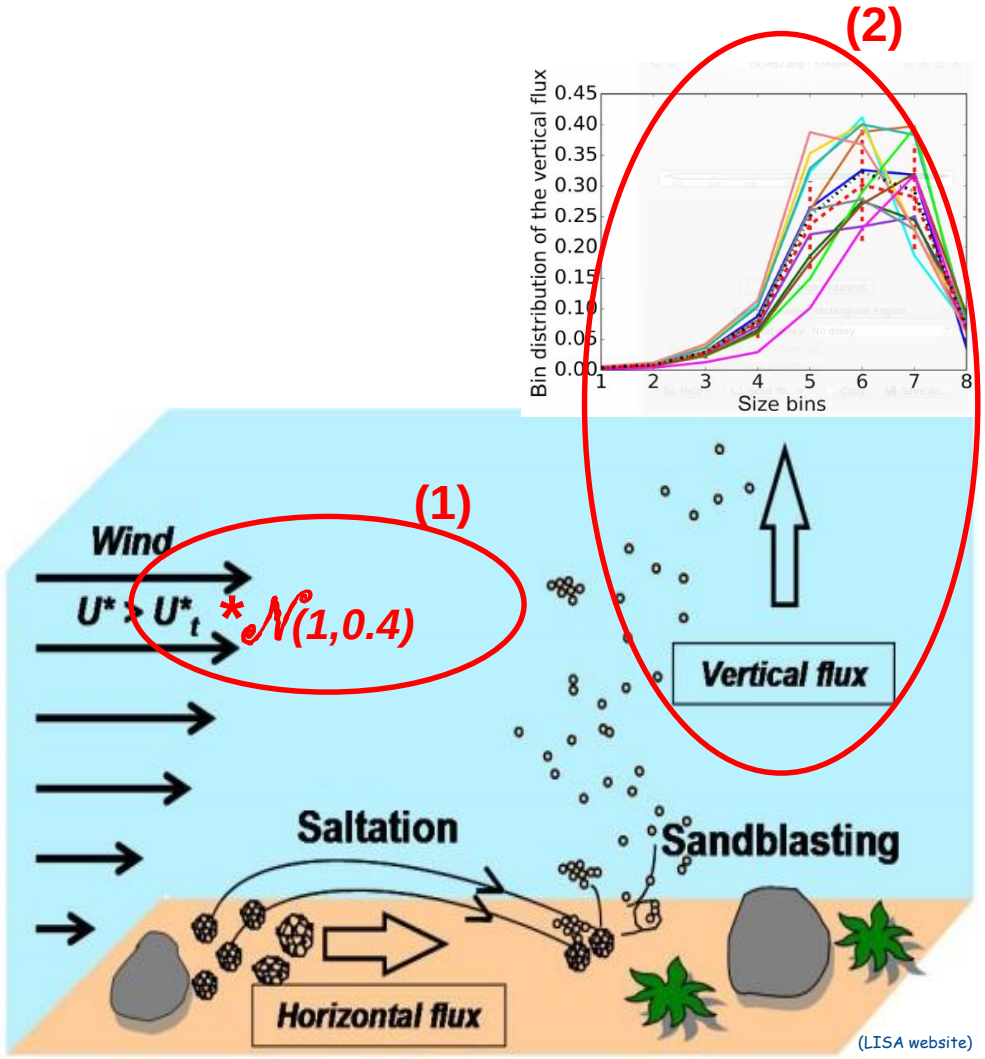
by perturbing:

(1) the threshold friction velocity

(2) the vertical flux of dust in each of the eight dust transport bins



Experiment design

An ensemble-based DA scheme: LETKF
- usage of a flow-dependent background error covariance
- performing the analysis locally

Experiment design

data assimilation

An ensemble-based DA scheme: LETKF
- usage of a flow-dependent background error covariance
- performing the analysis locally

observations

Dedicated dust observations:

- MODIS Dark Target and Deep Blue AOD in dust-dominated conditions
- MODIS Deep Blue coarse AOD
- IASI dust AOD

MODIS Dark Target and Deep Blue, Level3

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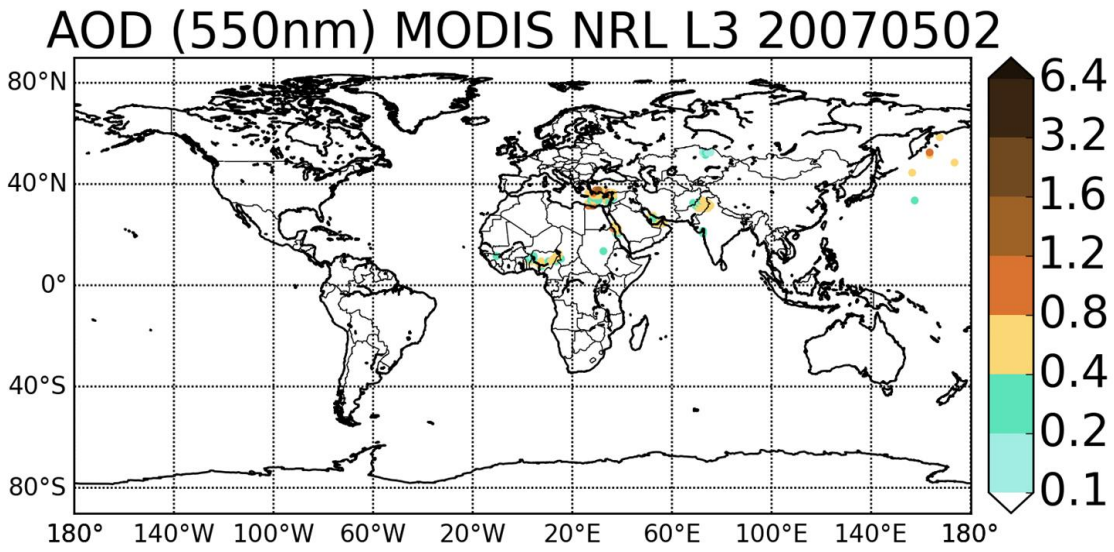
Assimilated observations

NRL MODIS Dark Target, L3 C5
- filtered and corrected,
- spatially aggregated,
- uncertainty estimation

(Zhang and Reid, 2006; Hyer et al., 2010; Shi et al., 2011)
- AE, AI filter for dust



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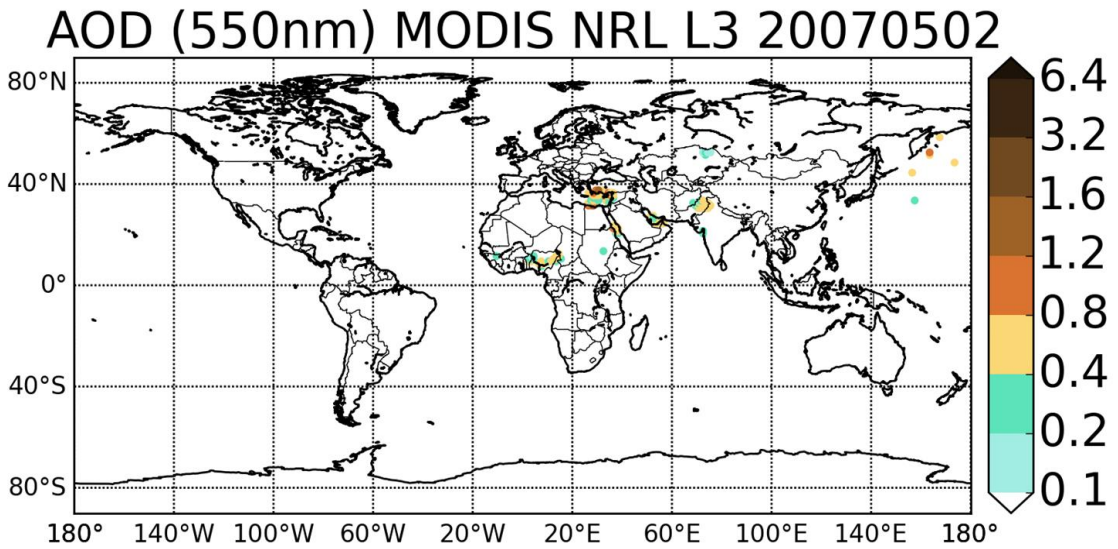
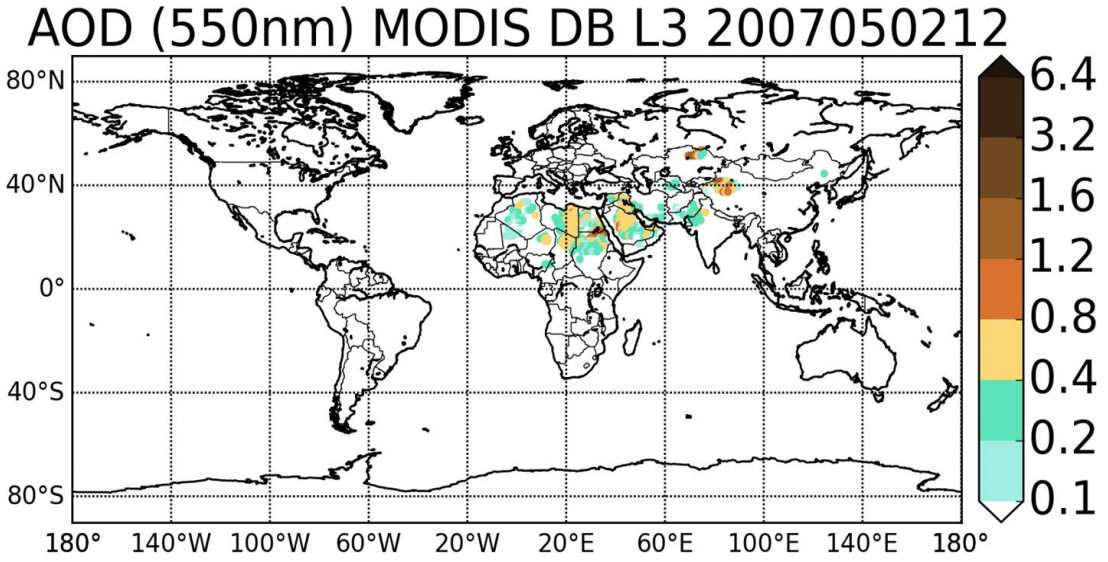


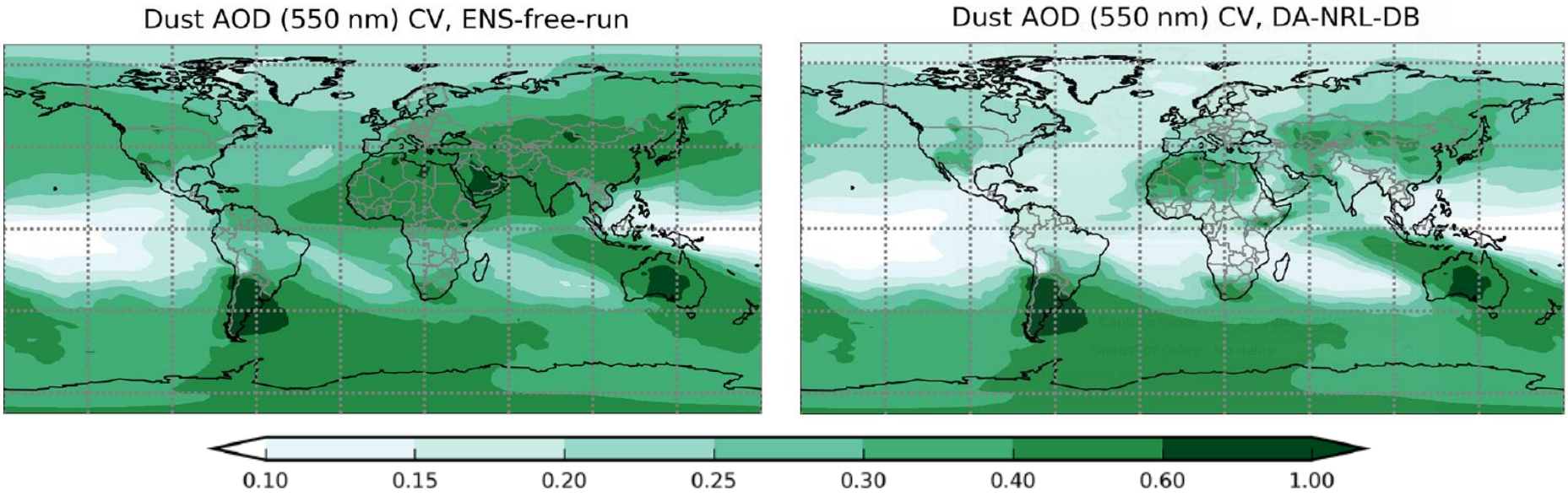
MODIS Deep Blue, L3 C6
- aggregation of highest quality L2
- uncertainty model for L2
(Sayer et al., 2014)
- AE, AI, counts filter
- uncertainty model for L3:
$\boldsymbol{\sigma_m^2 + \sigma_r^2}$



Ensemble Spread Reduction

Ensemble free run

Data assimilation run

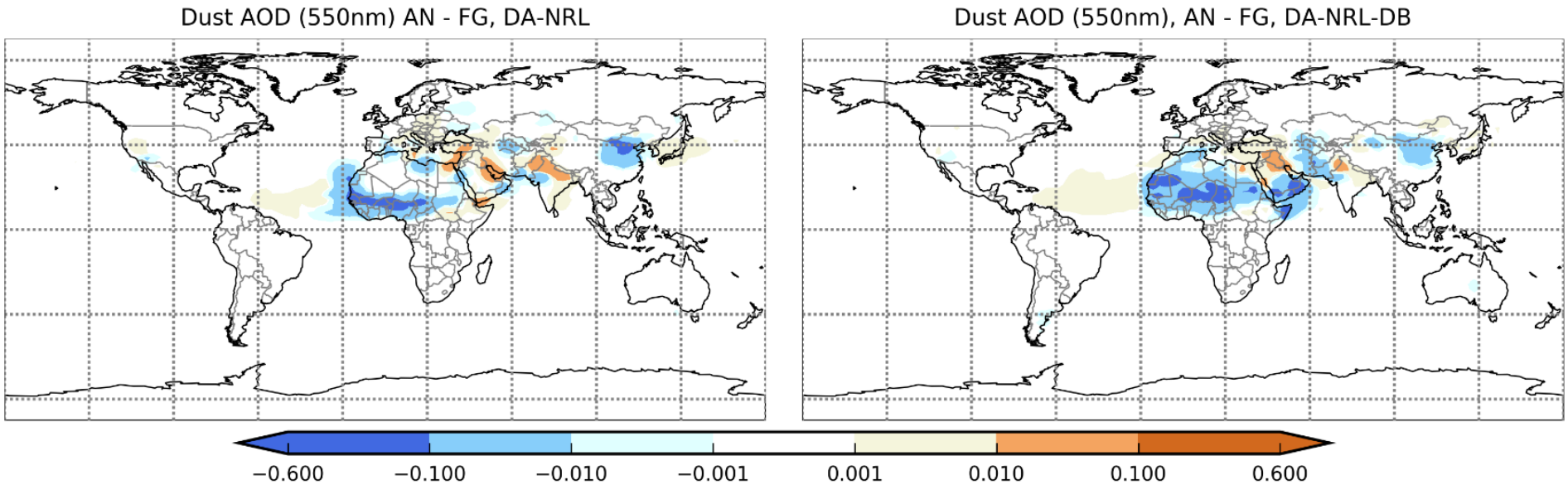


Data assimilation lowers the values of the coefficient of variation in the regions where observations are present, which indicates a reduction of the ensemble spread due to the assimilated observations

Analysis increments

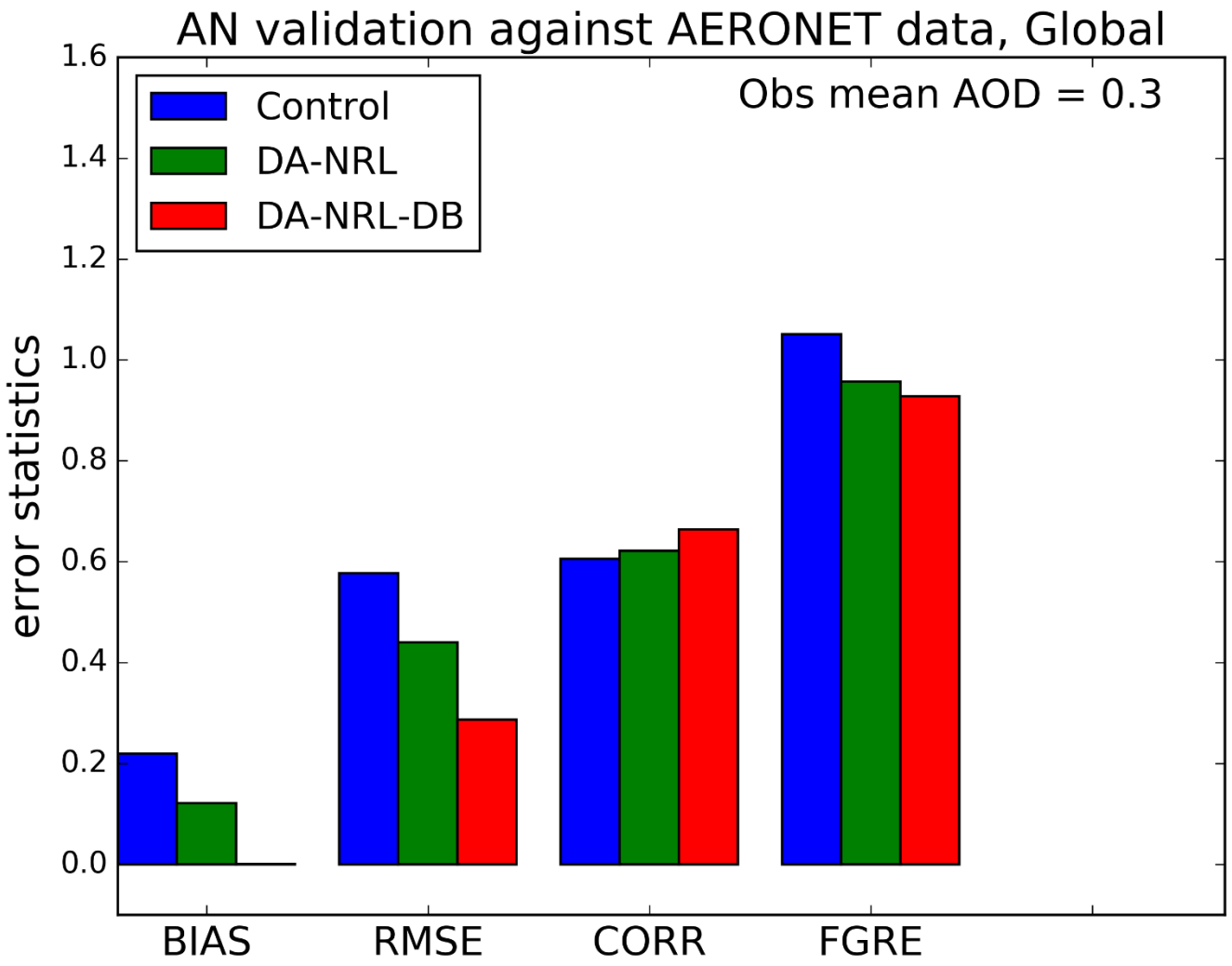
MODIS NRL

MODIS NRL +DB

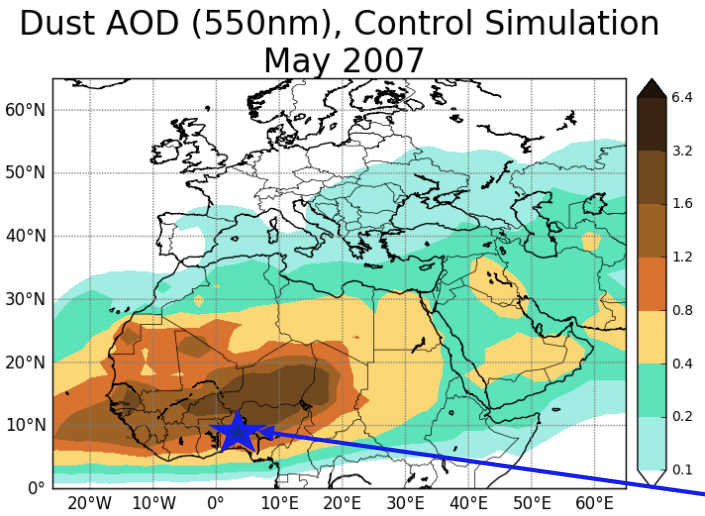


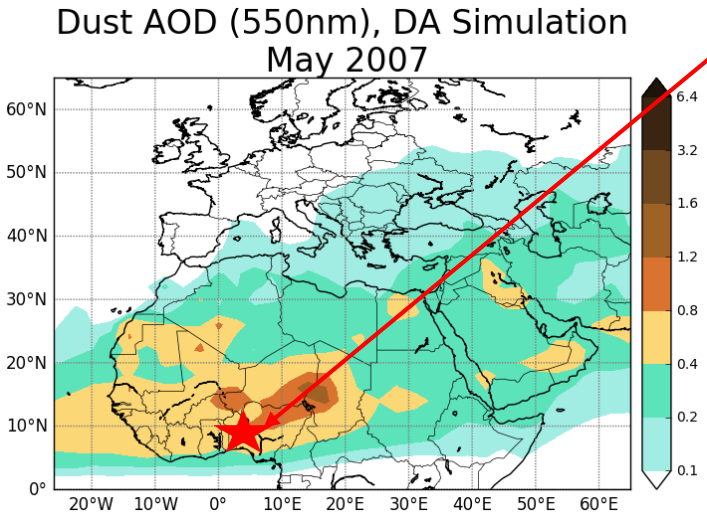
- Non-zero systematic increments are to be interpreted as systematic corrections that these sets of observations are making, in particular removing mass close to sources and, to a lesser extent, adding mass in the outflow.
- The spatial distribution of the increments highlights the role that MODIS Deep Blue observations play in particular over the Sahara dust sources

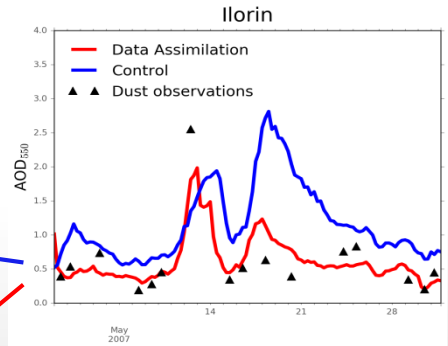
Validation of the analysis

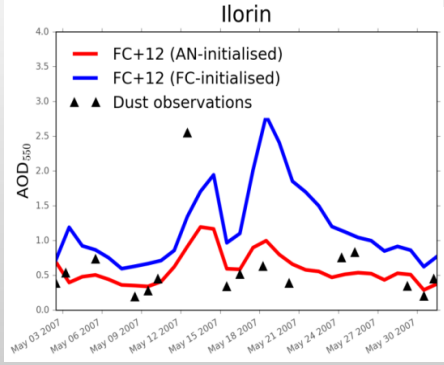


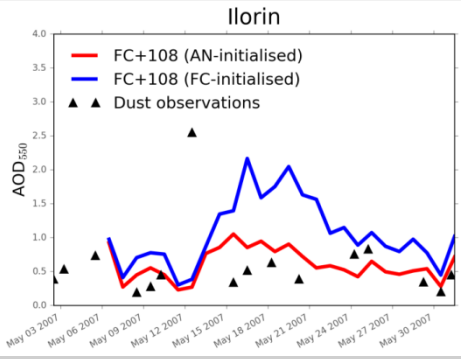
Validation of the forecast











Validation

Better description of current and forecast conditions for dust with data assimilation

AERONET site of independent sun photometer observations

MODIS Deep Blue, Level 2

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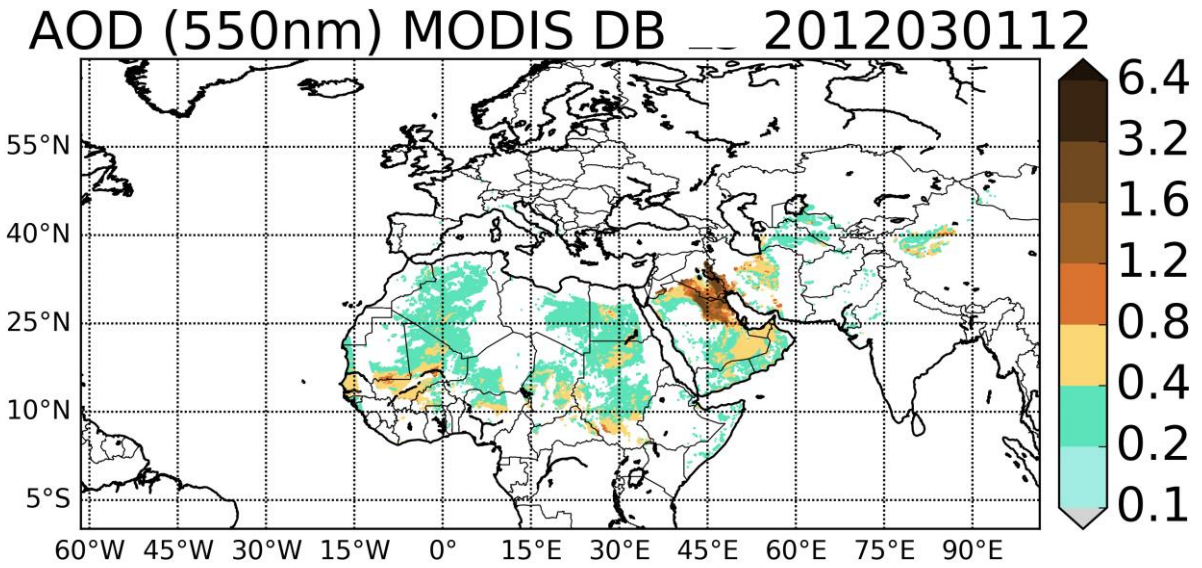
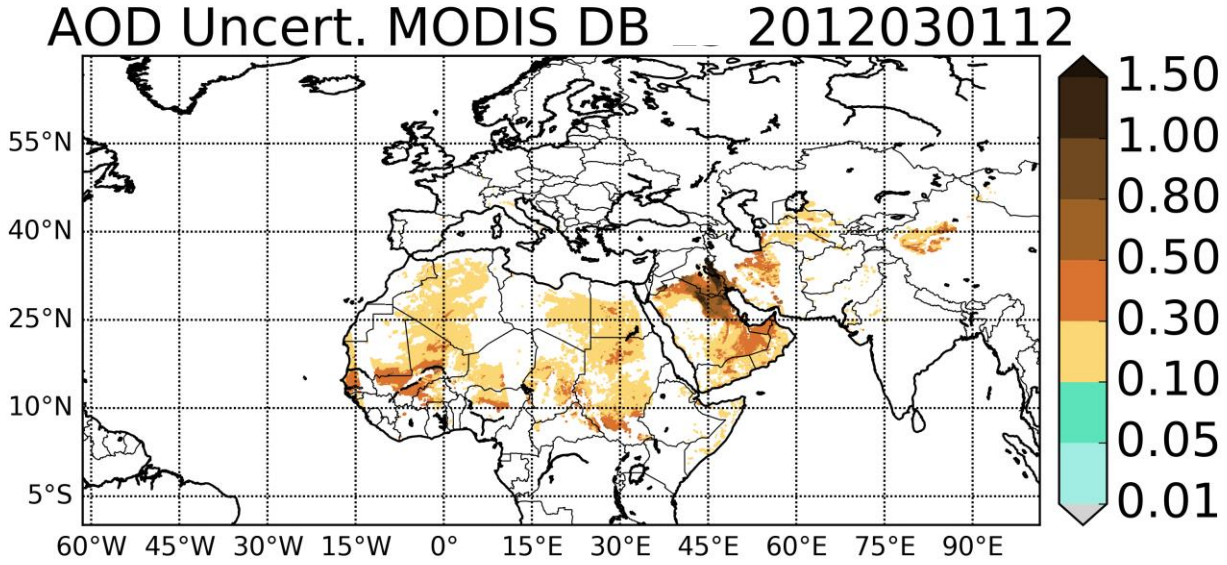
Assimilated observations

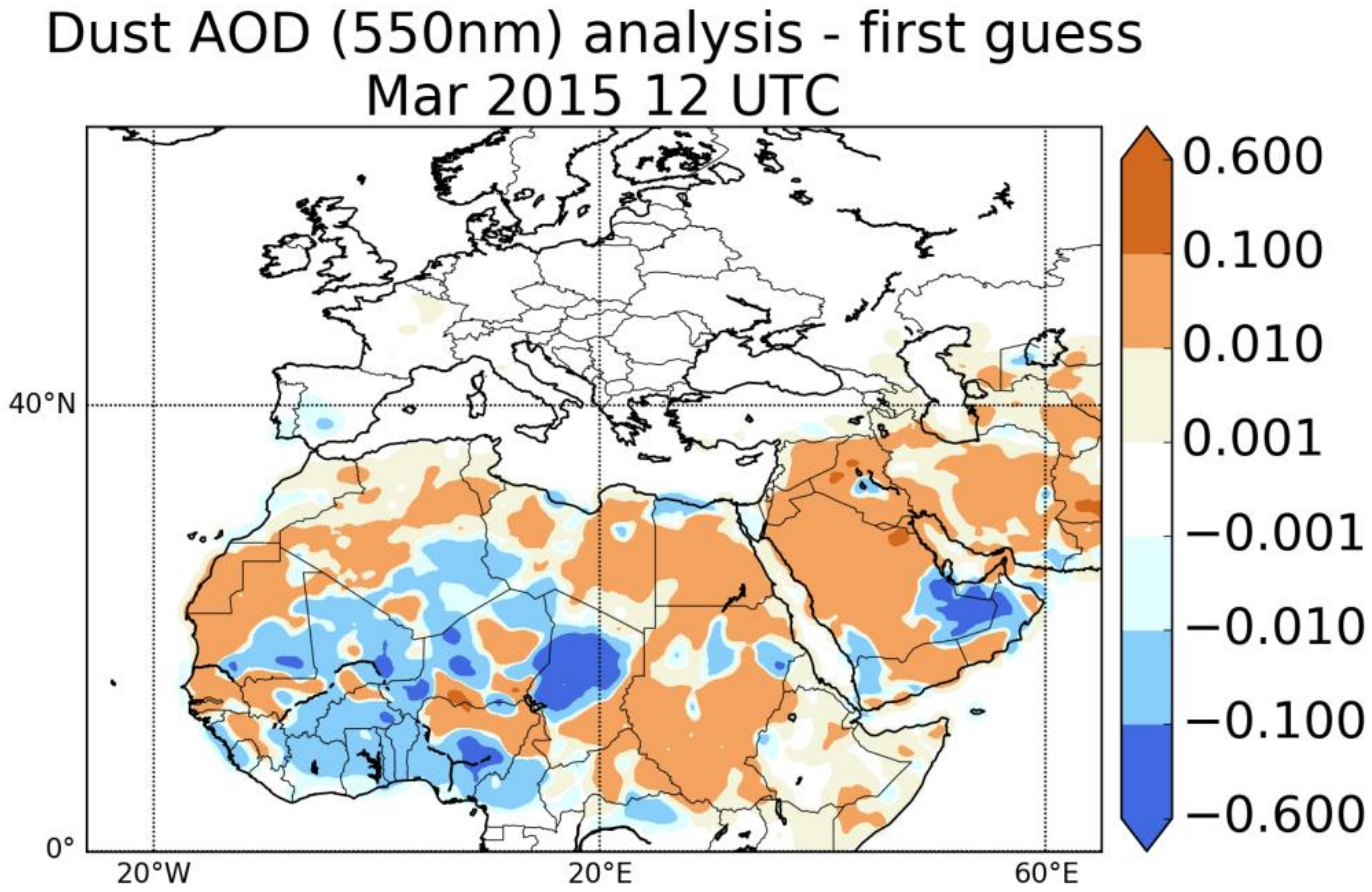
MODIS Deep Blue, L2 C6
- AE, ω filter , coarse AOD
- highest quality flag
(Ginoux et al., 2012, Pu & Ginoux, 2017)
- *uncertainty model based on Sayer et al., 2014*



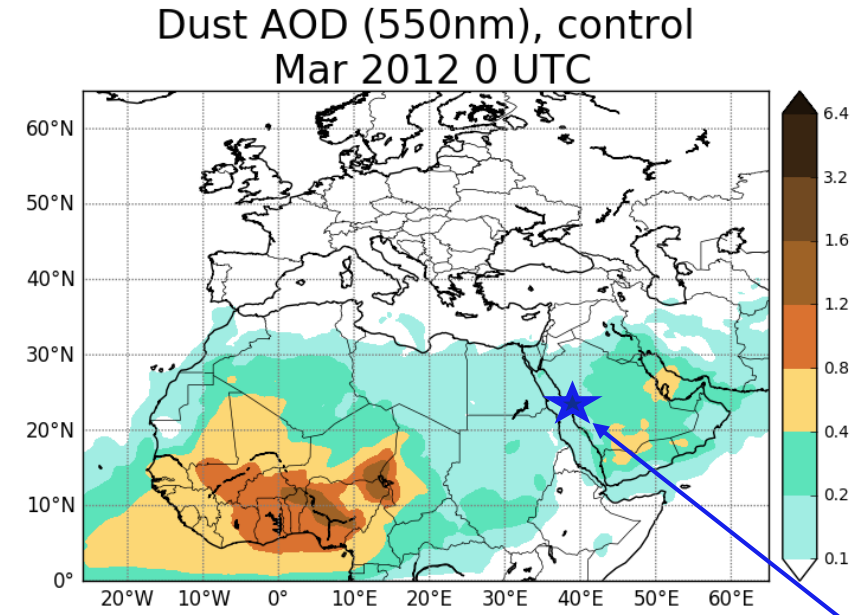


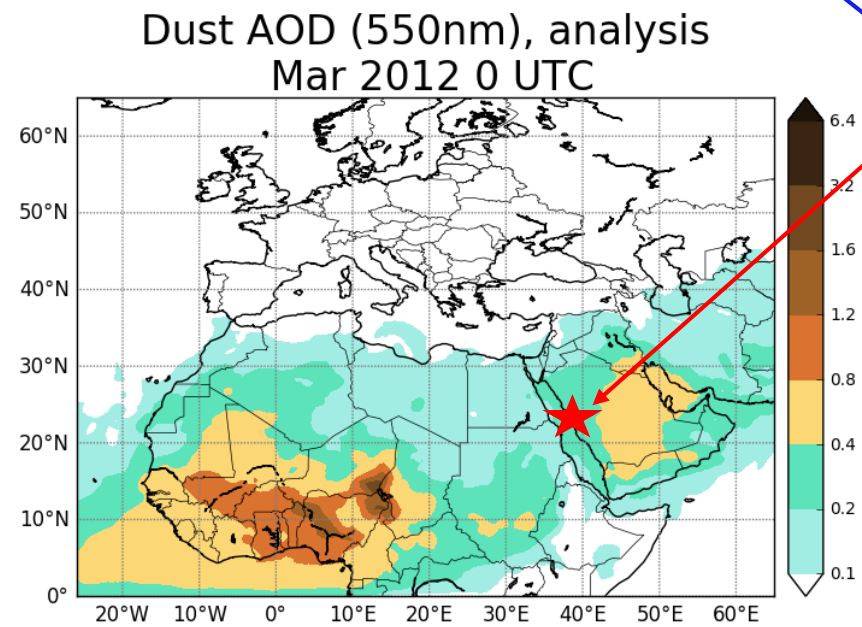
Analysis increments

Feedback from assimilation increments

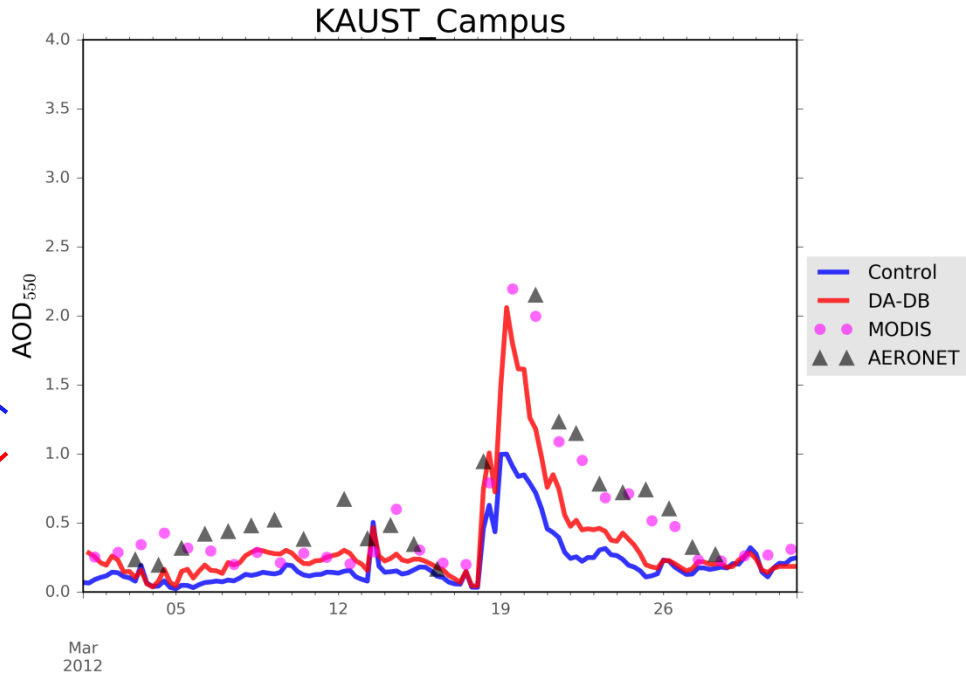


Indipendent validation

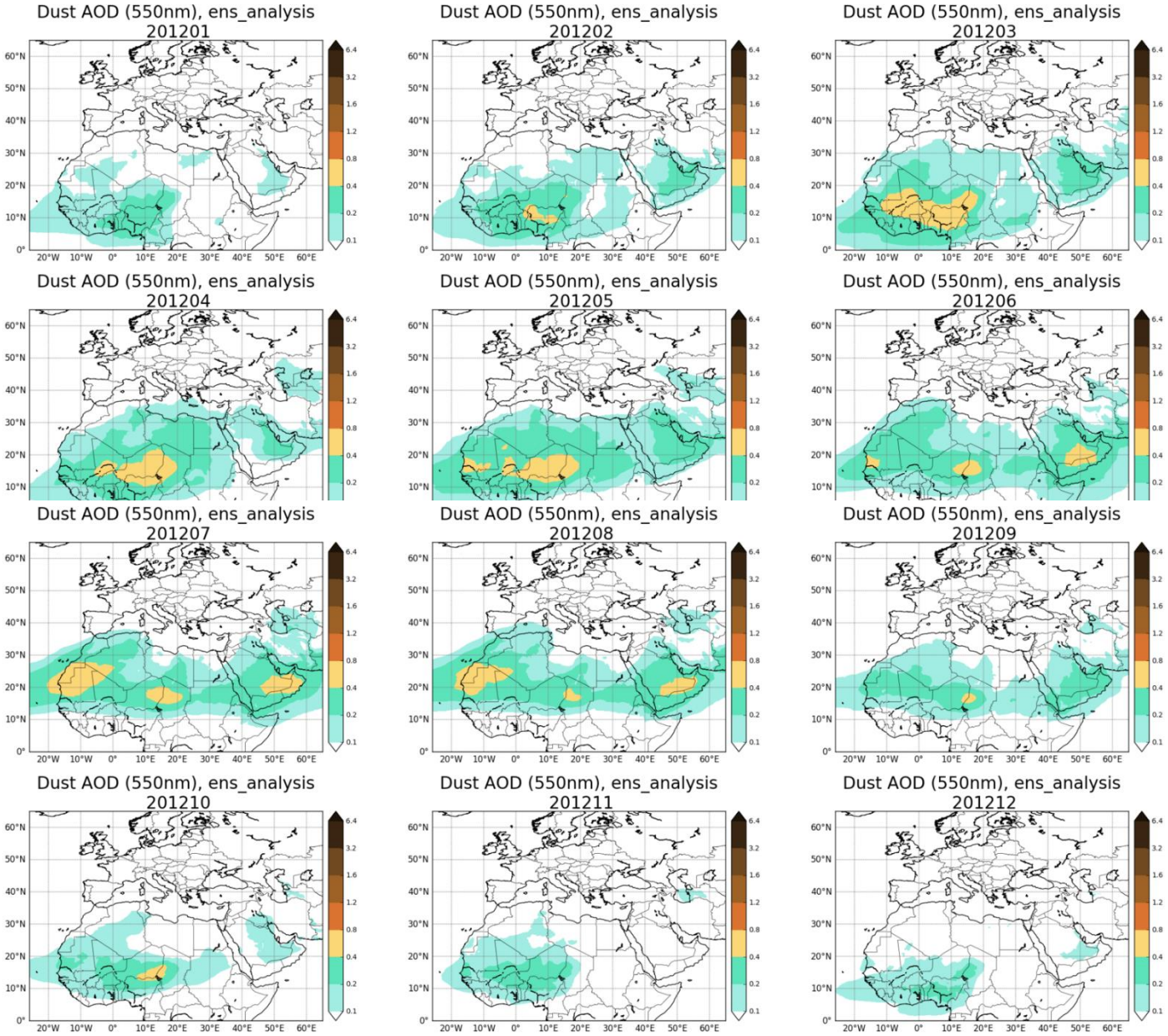




0.33ºx0.33º model resolution



Higher resolution analysis



Next step

DustClim

ERA4CS European Research Area for Climate Services

Produce an high resolution dust reanalysis for Northern Africa, Middle East and Europe covering the satellite era of quantitative aerosol information, and develop dust-related services tailored to specific socio-economic sectors.

BSC AEMet Agencia Estatal de Meteorología cnrs

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Thank you

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